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(54) **Method of correcting ultrasonic picture image**

(57) In an ultrasonic diagnostic apparatus for effecting sector scanning by reciprocating an ultrasonic vibrator in a forward direction and a reverse direction via a transmission mechanism and for providing an ultrasonic picture image in synchronism with an output signal from an encoder for detecting the position of the ultrasonic vibrator, distortion is caused by a positional shift of the ultrasonic vibrator due to backlash of the transmission mechanism in moving the ultrasonic vibrator in the forward and reverse directions. The method comprises the steps of generating an ultrasonic scan signal during the movement of the ultrasonic vibrator in the forward and reverse directions, adding a backlash correction signal to the ultrasonic scan signal to produce a picture signal corresponding to the ultrasonic picture image, and adjusting the magnitude of the backlash correction signal such that the picture signal is compensated for the amount of backlash of the transmission mechanism.

FIG. 3

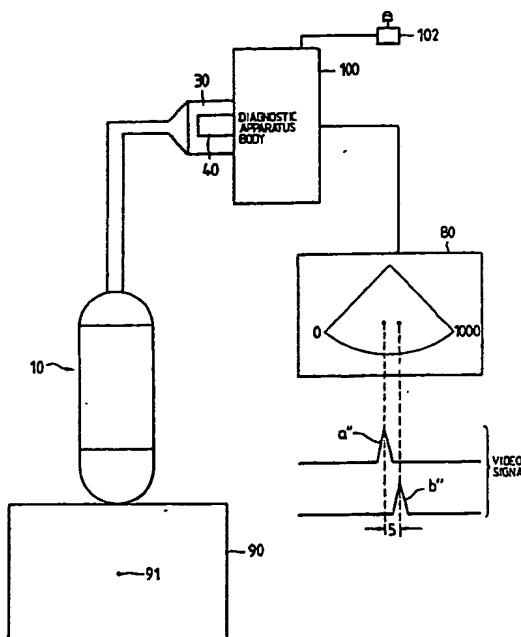


FIG. 1

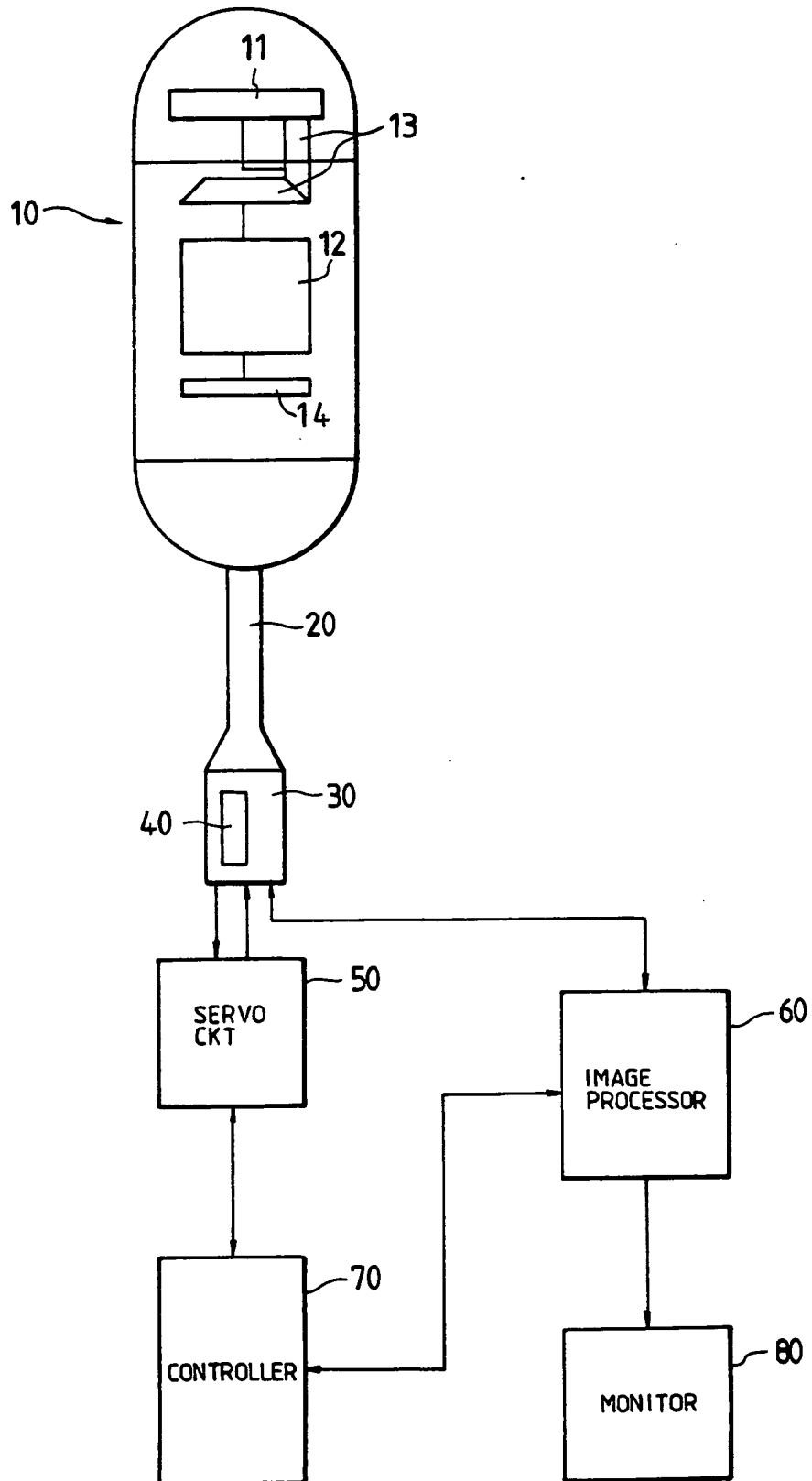


FIG. 2(a)

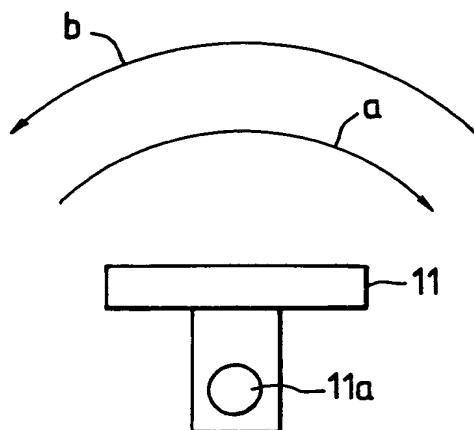


FIG. 2(b)

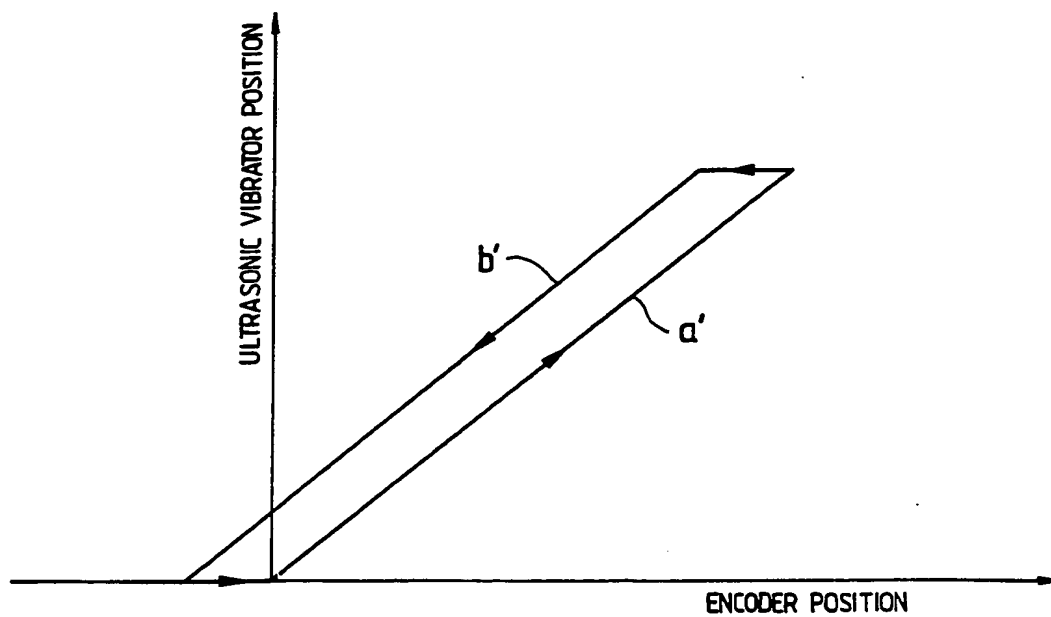
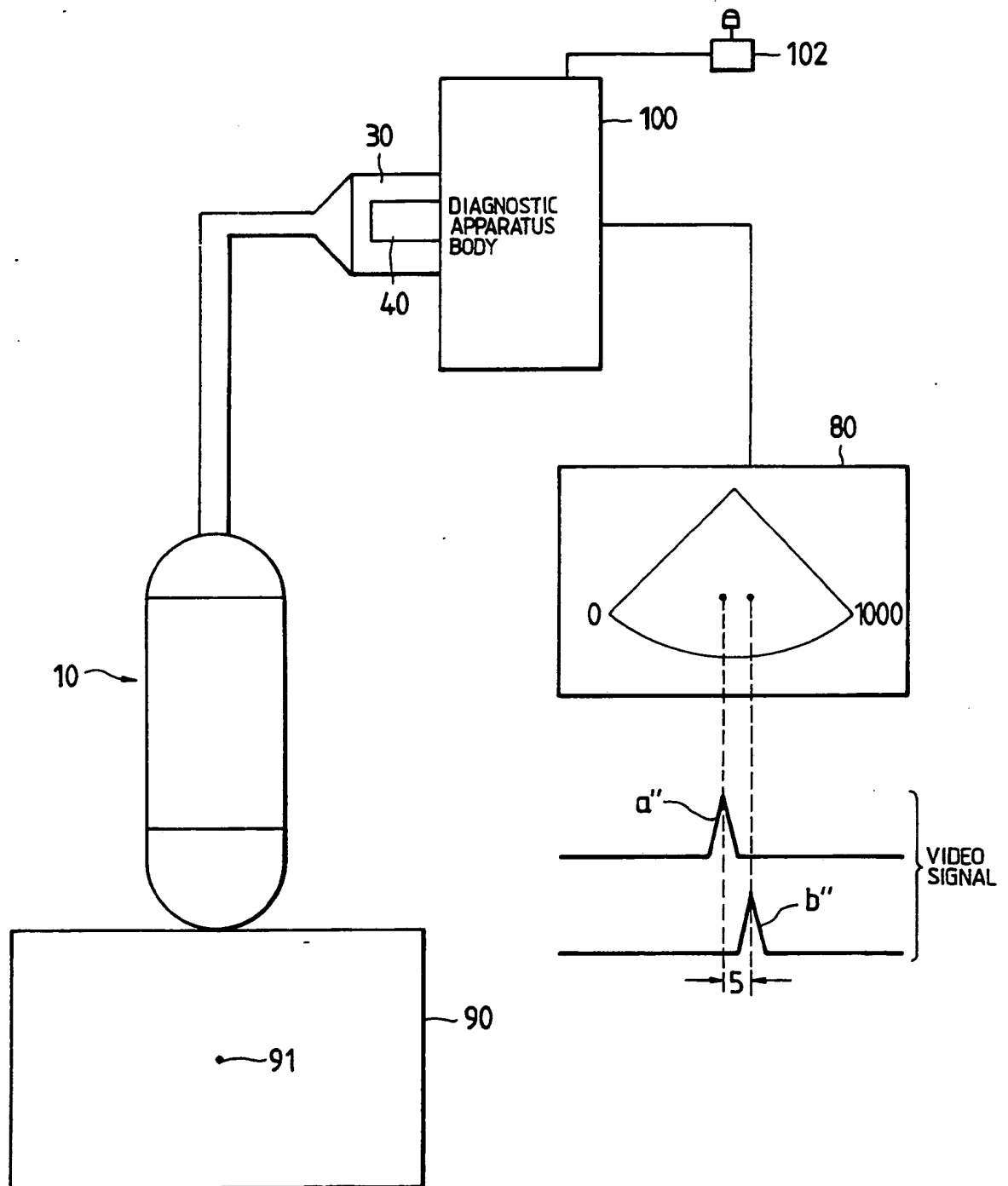


FIG. 3



METHOD OF CORRECTING ULTRASONIC PICTURE IMAGE

FIELD OF THE INVENTION

The present invention relates to a method of correcting an ultrasonic picture image, and more particularly to a method of correcting a positional shift of the ultrasonic picture image caused by backlash of a transmission mechanism upon effecting sector scanning by reciprocating an ultrasonic vibrator through a driving source and the transmission mechanism in an ultrasonic diagnostic apparatus.

BACKGROUND OF THE INVENTION

Conventionally, a sector scanning system is known as one for scanning a ultrasonic vibrator, which serves to receive and transmit ultrasonic waves, by reciprocating and oscillating the ultrasonic vibrator within a predetermined angular range. The ultrasonic vibrator according to the sector scanning system is driven by a combination of a driving source such as a motor, etc., and a well-known transmission mechanism using gears, etc. An encoder detects the rotary angle of the ultrasonic vibrator and outputs an output signal for synchronization of an ultrasonic picture image.

Such a transmission mechanism, however, suffers from mechanical play produced naturally or owing to wear over time, which may result in backlash. This causes the rotary position of the encoder to be shifted in the

forward and reverse scanning path with respect to the same position of the ultrasonic vibrator that is reciprocatably scanned by the transmission mechanism to result in shifting of the ultrasonic picture image of a subject under diagnosis.

To solve such difficulty, it is has been necessary to assemble with high precision the constituent precision parts of a transmission mechanism. This required high precision mechanical processing technology and processing facilities, and results in a longer time for processing and assembling and increases the cost of production.

SUMMARY OF THE INVENTION

In view of the drawbacks of the prior arts, an object of the present invention is a method of correcting electrically with an ultrasonic image to eliminate a positional shift of an ultrasonic picture image due to backlash without requiring severe processing and assembling accuracies for a transmission mechanism.

Another object of the present invention is a method of correcting an ultrasonic picture signal by eliminating the positional shift of the ultrasonic picture image as caused by backlash of a transmission mechanism by adding a correcting signal corresponding to the positional shift to an output signal from an encoder.

These and other objects of the present invention are accomplished in an ultrasonic diagnostic apparatus for effecting sector scanning by reciprocating an ultrasonic vibrator in a forward direction and a reverse direction via a transmission mechanism and for providing an ultrasonic picture image in synchronism with an output signal from an encoder for detecting the position of the ultrasonic vibrator by a method of correcting the ultrasonic picture image to eliminate distortion thereof caused by a positional shift of the ultrasonic vibrator due to backlash of the transmission mechanism in moving the ultrasonic vibrator in the forward and reverse directions, the method comprising the steps of generating an ultrasonic scan signal during the movement of the ultrasonic vibrator in the forward and reverse directions, adding a backlash correction signal to the ultrasonic scan signal to produce a picture signal corresponding to the ultrasonic picture image, and adjusting the magnitude of the backlash correction signal such that the picture signal is compensated for the amount of backlash of the transmission mechanism.

BRIEF DESCRIPTION OF THE DRAWINGS

The manner by which the above objects and other objects, features, and advantages of the present invention are attained will be fully apparent from the following

detailed description when it is considered in view of the drawings, wherein:

Fig. 1 is a view illustrating in a simplified form an ultrasonic diagnostic apparatus;

Fig. 2(a) is a view illustrating reciprocative motion of an ultrasonic vibrator;

Fig. 2(b) is a view of characteristics illustrating a positional relation between an encoder and the ultrasonic vibrator; and

Fig. 3 is a view illustrating the arrangement of an apparatus for correcting a positional shift of an ultrasonic picture image.

DETAILED DESCRIPTION OF THE INVENTION

In the present invention, a positional shift of the encoder is allowable with respect to the same position of the ultrasonic vibration in its reciprocative motion. This positional shift of the encoder, however, causes a positional shift of an ultrasonic picture image owing to backlash of the transmission mechanism if the output signal from the encoder is employed for establishing synchronization of the ultrasonic picture image. The present invention corrects the positional shift of the ultrasonic image in conformity with a correcting signal by adding the correcting signal to the encoder output signal

and generating the ultrasonic picture image in synchronism with the correcting signal.

Referring to Fig. 1, an ultrasonic diagnostic apparatus, to which the present embodiment is applied, is illustrated in a simplified form. An ultrasonic diagnostic probe 10, e.g., a mechanical probe, includes an ultrasonic vibrator 11 for transmission and reception of ultrasonic waves between the probe and a subject under diagnosis, a motor 12 as a driving source, a bevel gear 13 as a transmission mechanism for reciprocating the ultrasonic vibrator 11 within a predetermined angular range (e.g., $\pm 45^\circ$), and an encoder 14 for detecting the rotary angle of the motor 12, and thereby the position of the ultrasonic vibrator 11.

The probe 10 is connected to a connector 30 through a cable 20. The connector 30 includes a digital switch 40, for example, composed of 4 bits, for correcting a positional shift of the ultrasonic image due to backlash of the bevel gear 13 as described below.

A servo circuit 50 is connected to the probe 10 via the connector 30, and an image processor 60 processes the ultrasonic picture image in synchronism with an output signal from the encoder 14. A controller 70 controls the servo circuit 50 and the image processor 60, and a monitor 80 is connected to the image processor 60.

In this arrangement, the encoder 14, in synchronism with the motor 12 and the ultrasonic vibrator 11, satisfies a positional relation as illustrated in Fig. 2(b). When the ultrasonic vibrator 11 is reciprocated in the forward direction a (Fig. 2(a)) and in the reverse direction b around the rotary shaft 11a of the ultrasonic vibrator 11, the position of the encoder 11 will vary from an intended position because of backlash of the bevel gear 13 in the path of the reciprocation. This causes a positional shift of the ultrasonic picture image in synchronism with the output signal from the encoder 14. Positional characteristics designated at a' and b' in Fig. 2(b) correspond to the directions of a and b in the Fig. 2(a).

The present invention effects electrical correction such that the positional characteristics a' and b' coincide with each other. Fig. 3 illustrates the arrangement of an apparatus for use in such correction. A wire target 90, for image correction, includes a wire 91 that is photographed by the probe 10 provided in the vicinity of the wire target 90. Moreover, the connector 30 is connected to a diagnostic apparatus body 100 including in an integral from the servo circuit 50, image processor 60, and controller 70.

Reciprocation, in this situation, of the ultrasonic vibrator 11 housed in the probe 10 caused by operation of the motor 12 and the bevel gear 13 results in two ultrasonic picture images of the wire 91 on the monitor 80 as described previously and illustrated in Fig. 3. Waveforms a", b" as shown below the monitor 80 designates video signals corresponding to the picture images of the wire 91 on the monitor 80.

In order to eliminate the positional shifts of the image, i.e., the shifts between the waveforms a", b", a backlash correcting signal of a proper magnitude is set by operation of the digital switch 40 concerning scanning of the ultrasonic vibrator in the b direction (or the a direction) shown in Fig. 2(a). The correcting signal may be added to the output signal from the encoder 14 during scanning in the b direction (or in the a direction) to adjust a synchronizing signal of the ultrasonic image. The adjustment of the correcting signal is determined by observing the monitor 50 and changing the value of the correcting signal until the two images of the wire 91 coincide with each other. This is accomplished by manipulations of the correcting signal control knob 102 by the operator.

That is, the present embodiment is to correct the output signal from the encoder 14 during the scanning of

the ultrasonic vibrator 11 in the forward and reverse movements thereof to cause the two picture images on the monitor 80 to coincide, whereby the positional shift of the ultrasonic image can be eliminated even where backlash of the bevel gear 13 occurs.

The operation of correcting the ultrasonic picture image will be concretely described hereinafter in a case where a digital switch of 4 bits is used.

The digital switch 40 can output 15 numerical values from 1 to 15 each of which is used as a correcting signal to an output signal of the encoder 14. For example, in a case where the value of the output signal of the encoder 14 is 1000 for the last position of the going passage of the ultrasonic vibrator 11 as shown in Fig. 3 and the output value of the digital switch 40 is 5 for the backlash corresponding to the shift between the peaks of the waveforms a" and b" as shown in Fig. 3, an ultrasonic picture image for the returning passage is formed in synchronization with the value obtained by adding the amount of the backlash (5) to a value of each output signal of the encoder 14, thereby coinciding the ultrasonic picture images between the going and returning passages of the ultrasonic vibrator 11. Accordingly, in the case as shown in Fig. 3, the operation of the digital switch 40 is carried out while the output numerical value

thereof is successively increased from 1, and is finished when the output numerical value reaches 5, thereby completing correction of backlash.

Although the present embodiment was applied to an oscillating sector scanning system, the present invention may further be applied to a rotating oscillation type where a plurality of ultrasonic vibrators are mounted around a rotating drum, and further ultrasonic diagnostic sector scanning systems of all sorts where ultrasonic waves are transmitted and received along a parallel line with use of a rotating vibrator and a parabolic reflecting mirror.

According to the present invention, as described above, a positional shift of a ultrasonic picture image due to backlash of the transmission mechanism can be corrected electrically with ease without requiring any means to improve the accuracy of the parts and their assembly of the transmission mechanism to remove the backlash itself. Thus, the production cost of the ultrasonic diagnostic apparatus is lowered.

Additionally, the present invention can correct any positional shift of a ultrasonic picture image at need even when such backlash is increased owing to the elapse of time to result in further severe positional shift being caused, whereby reduction of running is assured differing

from prior replacement of parts of the transmission mechanism.

CLAIMS

1. In an ultrasonic diagnostic apparatus for effecting sector scanning by reciprocating an ultrasonic vibrator in a forward direction and a reverse direction via a transmission mechanism a method of correcting the ultrasonic picture image to eliminate distortion thereof caused by a positional shift of the ultrasonic vibrator due to backlash of the transmission mechanism in moving the ultrasonic vibrator in the forward and reverse directions, comprising the steps of:

generating an ultrasonic scan signal during the movement of the ultrasonic vibrator in the forward and reverse directions;

adding a backlash correction signal to the ultrasonic scan signal to produce a picture signal corresponding to the ultrasonic picture image; and

adjusting the magnitude of the backlash correction signal such that the picture signal is compensated for the amount of backlash of the transmission mechanism.

2. A method according to claim 1, wherein said step of adjusting comprises the substeps of:

displaying the picture signal on a monitor in a manner to indicate the amount of shift in the ultrasonic picture image corresponding to the backlash of the transmission mechanism; and

changing the magnitude of the backlash correction signal to eliminate the shift of the ultrasonic picture image displayed on the monitor.

3. A method according to claim 2, wherein the substep of displaying the picture signal on a monitor in a manner to indicate the amount of shift in the ultrasonic picture image corresponding to the backlash of the transmission mechanism comprises the further substeps of:

displaying on the monitor first and second ultrasonic picture signals corresponding to the outputs of the ultrasonic vibrator during movement of the ultrasonic vibrator in the torward and reverse directions, respectively, said displayed first ultrasonic picture signal being shifted on the monitor from said second ultrasonic picture signal by an amount corresponding to the backlash of the transmission mechanism.